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The characterization of the dynamics of a continuous gravity current

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The present work investigates the dynamical characteristics of a gravity current produced by a continuous and steady release of a dense fluid, with a source density ρ_0 , into a lighter ambient fluid, with density $\rho_a < \rho_0$. A planar geometry is considered in which the ambient fluid is initially at rest inside a rectangular tank and the dense current is continuously released from a source located at the bottom-left corner of the tank. The released current propagates along the horizontal bottom boundary of the domain displacing the ambient fluid. This configuration has been considered experimentally by Sher & Woods (2017). A numerical study has been carried out using the Direct Numerical Simulations (DNS) of the governing equations via the NEK5000 solver. Instantaneous three-dimensional velocity, pressure and density fields were extracted and two-dimensionalized by width-averaging. The state of the release is characterized by the source Froude number $Fr_0 = u_0 / \sqrt{g'_0 h_0}$ with u_0 being the velocity of the release, h_0 being the height at the inlet, and $g'_0 = g(\rho_0 - \rho_a) / \rho_a$ being the source buoyancy. Throughout the series of simulations, we control the state of the current at the source by only varying the source density ρ_0 , resulting in a range of source Froude number between $0.6 < Fr_0 < 2.7$, and we seek to record the effects of this variation on the dynamics. The source discharge $Q_0 = u_0 h_0$ and buoyancy flux $B_0 = Q_0 g'_0$ are kept constant over time. The front speed, u_f , was shown to remain steady; a well-known feature of continuous gravity currents. A dimensionless parameter, $\lambda = u_f / B_0^{1/3}$, that characterizes the front speed was computed as a function of Fr_0 and the result shows a good agreement with the range recorded by Sher & Woods (2017). The entrainment of ambient fluid into the current is parametrized with two methods. First, we estimate the rate of change of the volume of the current, dV/dt , and we recorded the range $1.8Q_0 < dV/dt < 2.1Q_0$ for the selected Fr_0 range. Secondly, the theory of inclined plumes introduced by Ellison & Turner (1959) was considered to estimate a local entrainment parameter, E , as a function of the local stratification represented by the local Richardson number Ri . The well-known relation, E proportional to Ri^{-1} , was held when $Ri < 0.8$; otherwise, the entrainment parameter tends to near-zero values.